Earth Science Informatics - Overview

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Topics

- Informatics
- Earth Science Informatics
- IEEE GRSS
- ESI Technical Committee
- Major “players” in the world
- NASA’s involvement – Earth Observing System Data and Information System (EOSDIS)
- Conclusion

NASA's Earth Science Data Systems

- "Advance understanding of Earth and develop technologies to improve the quality of life on our home planet." -- *2014 NASA Strategic Plan*
- NASA's Earth Science Data Systems directly support this strategic goal by providing end-to-end capabilities to deliver data and information products to users
- NASA's Earth Science Data and Information Policy promotes usage of data by the community
  - No period of exclusive access - Data are available after initial checkout
  - Data available at no cost to all users on a non-discriminatory basis except where agreed upon with international partners

Core and Community Capabilities

- **Core Capabilities**
  - Basic operational capabilities to process, archive, manage and distribute data from NASA missions
    - Earth Observing System Data and Information System (EOSDIS)
    - Precipitation Processing System – NASA GSFC
    - Laboratory for Atmospheric and Space Physics (LASP) Interactive Solar Irradiance Data Center - University of Colorado
    - CloudSat Data Processing Center – Colorado State University
- **Community Capabilities**
  - Peer-review-selected projects
  - New data products – Making Earth System Data Records for Use in Research Environments (MEaSUREs)
  - Research in Earth Science Informatics to feed into the evolution of the core components
    - Applied Information Systems Technology (AIST)
    - Advancing Collaborative Connections for Earth System Science (ACCESS)

Earth Observing System Data and Information System (EOSDIS)

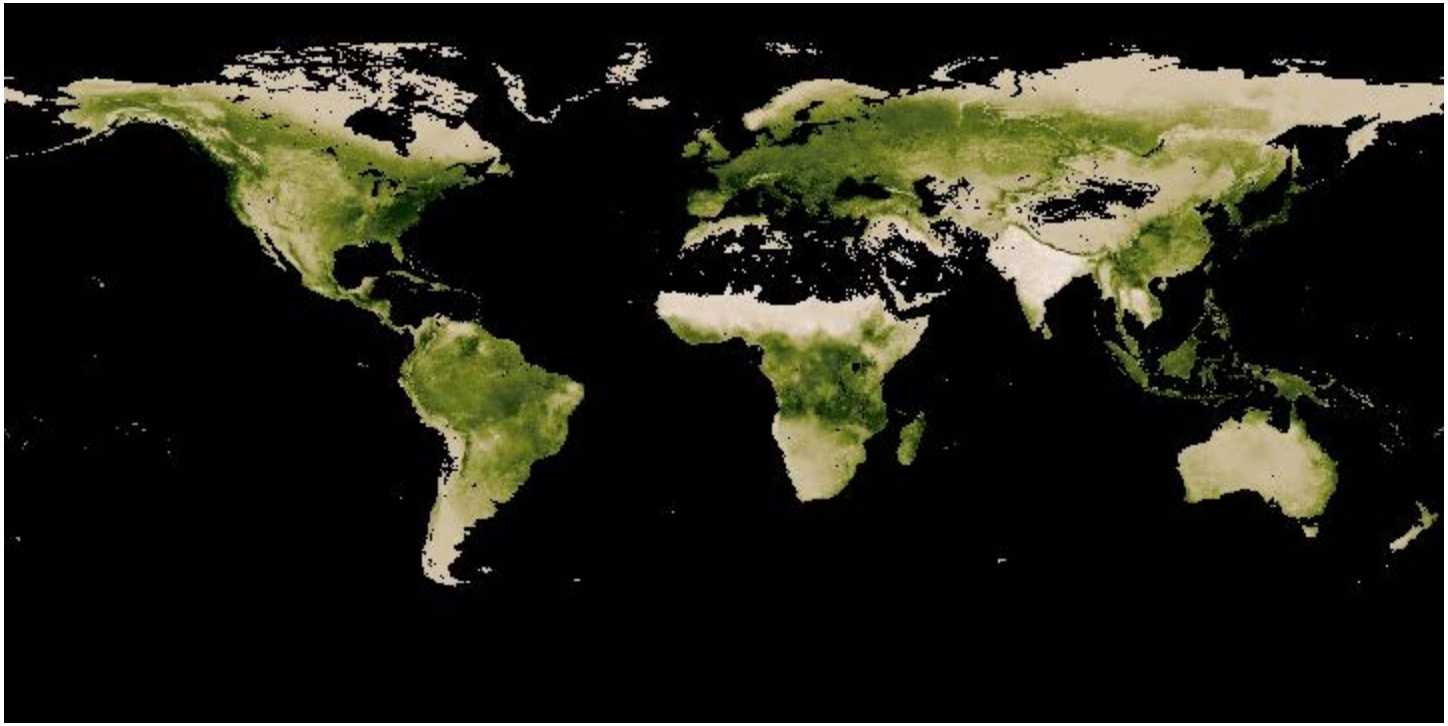
- Major core capability in NASA's Earth Science Data Systems Program.
- In operation since August 1994
- Provides end-to-end capabilities for managing NASA's Earth science data.
  - Science Operations
    - Science data processing
    - Data management
    - Interoperable distributed data archives
    - On-line data access services
    - Earth science discipline-oriented user services
  - Network Data Transport to distributed system elements

Extensive Data Collection

- **> 8200 data types (collections)**
  - Land
    - » Cover & Usage
    - » Surface temperature
    - » Soil moisture
    - » Surface topography
  - Atmosphere
    - » Winds & Precipitation
    - » Aerosols & Clouds
    - » Temperature & Humidity
    - » Solar radiation
  - Ocean
    - » Surface temperature
    - » Surface wind fields & Heat flux
    - » Surface topography
    - » Ocean color
  - Cryosphere
    - » Sea/Land Ice & Snow Cover

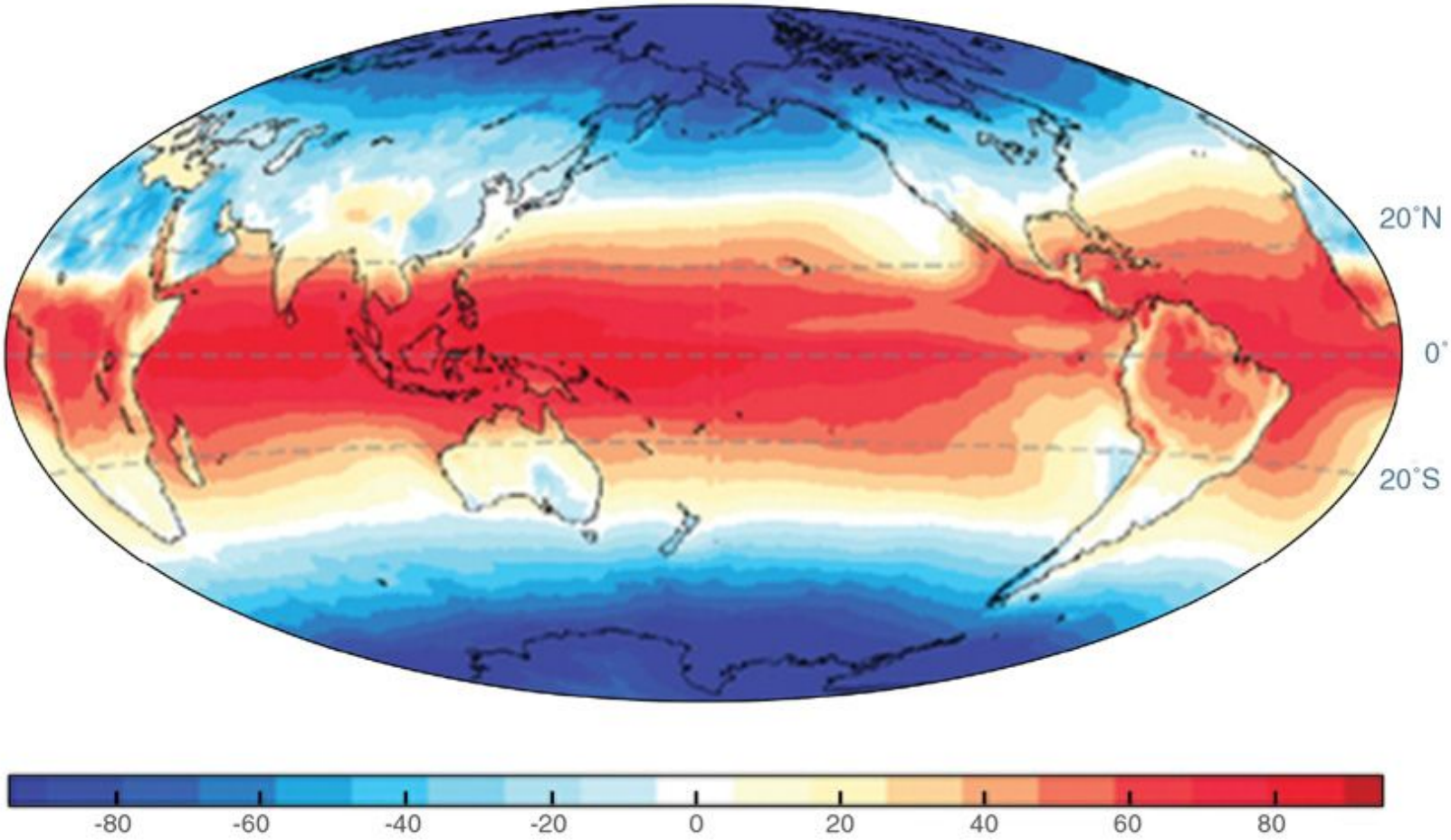
- Human Dimensions
  - » Population & Land Use
  - » Human & Environmental Health
  - » Ecosystems

Global Net Primary Productivity



Net Primary Productivity is the amount of carbon absorbed by plants minus carbon released by plants, measured in grams of carbon per square meter per day. Image shows the averages over May 15, globally. Credits - Image made by Reto Stockli, NASA's Earth Observatory Team, using data provided by the MODIS Land Science Team

Top of Atmosphere Radiation



At the top of the atmosphere (TOA), incoming and outgoing radiation determine Earth's average temperature. This image shows averaged net downward TOA radiation from the Clouds and Earth's Radiant Energy System (CERES) instrument from 2001 to 2010. The Southern Hemisphere receives more net radiation than the Northern Hemisphere. (Courtesy D. Frierson et al., 2013, Nature Geoscience) – accessed through https://earthdata.nasa.gov/user-resources/sensing-our-planet/rooting-out-rainfall

Air Quality in Northeastern China (1 of 2)

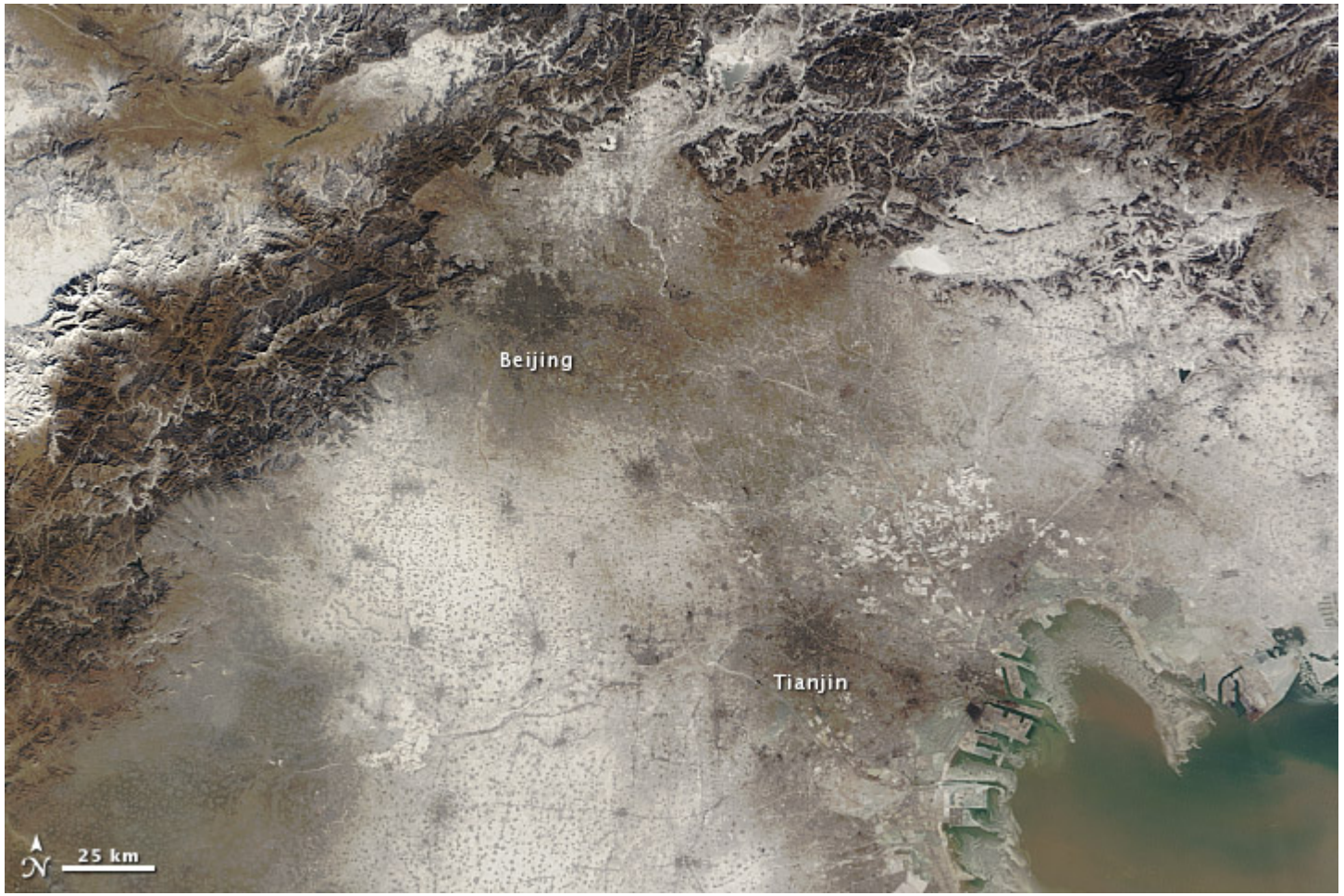


Image acquired by Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite on January 3, 2013 - NASA image courtesy Jeff Schmaltz, LANCE MODIS Rapid Response.

Air Quality in Northeastern China (2 of 2)

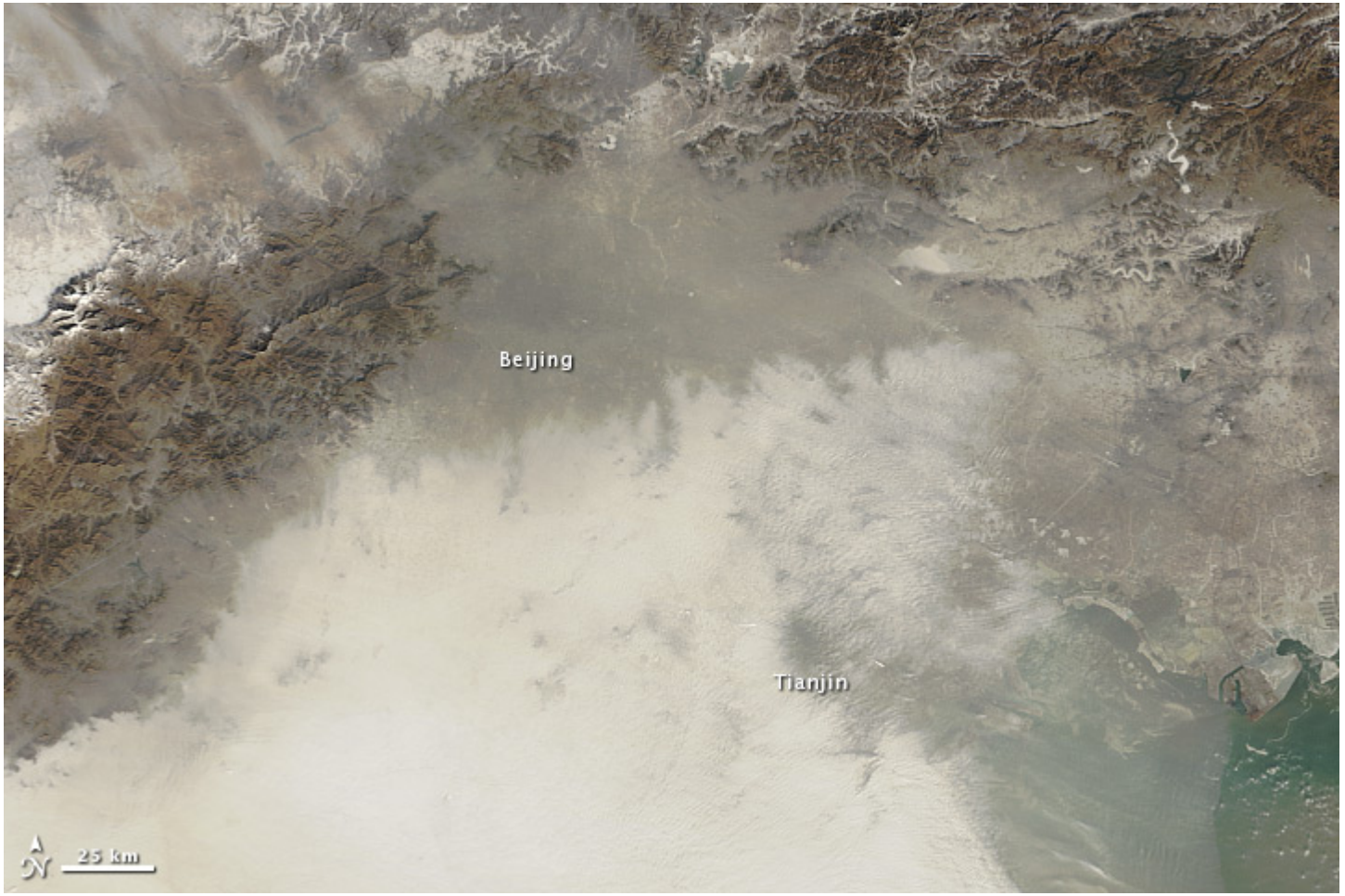
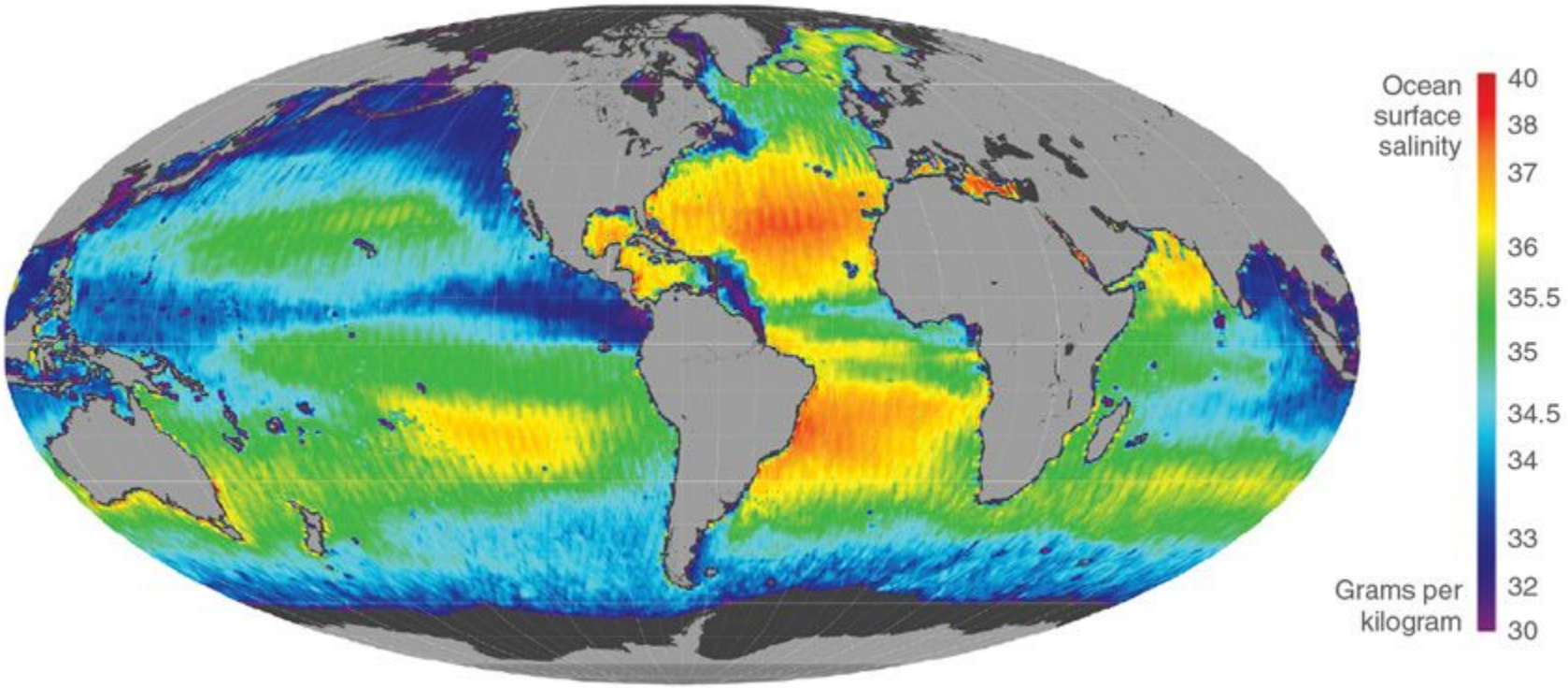


Image acquired by Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite on January 14, 2013 - NASA image courtesy Jeff Schmaltz, LANCE MODIS Rapid Response.

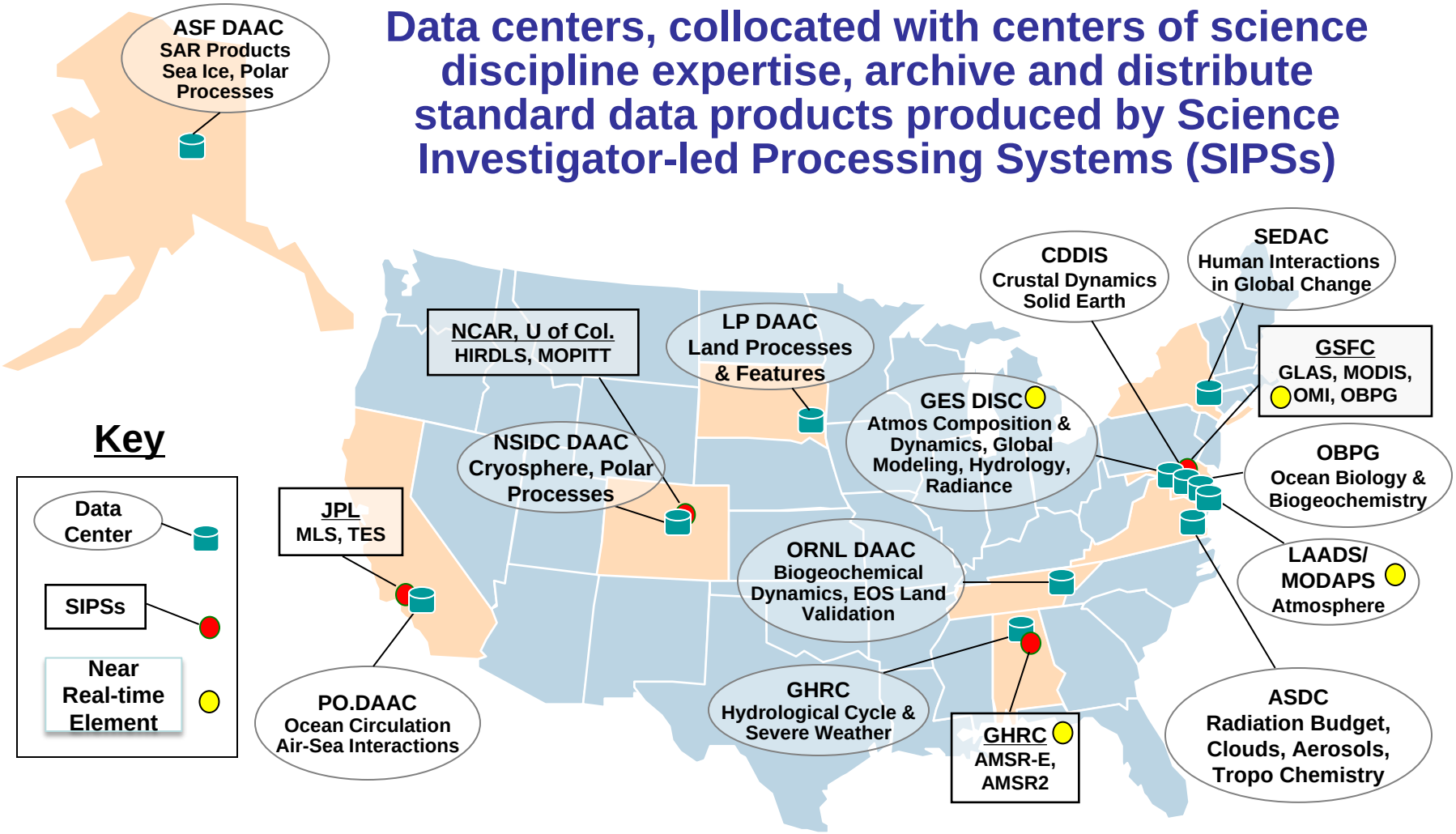
Sea Surface Salinity



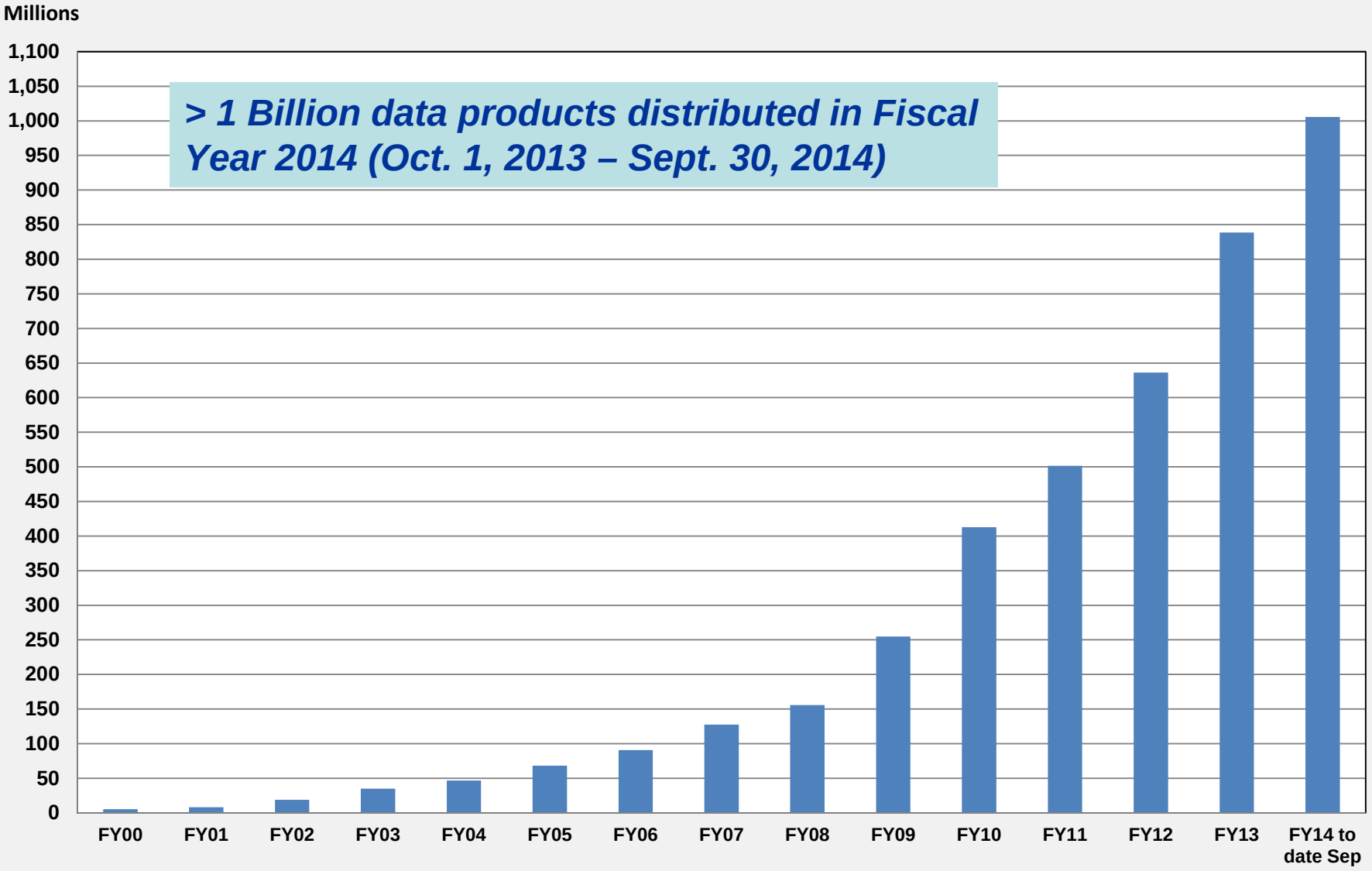
This image of Aquarius sea surface salinity (SSS) measurements averaged for 2012 shows a global color scale of salinity intensity. Warm colors mark stronger salinity values. Values are shown in a range between 30 grams per kilogram (purple) and 40 grams per kilogram (red). (Courtesy N. Kuring/NASA) – accessed through https://earthdata.nasa.gov/user-resources/sensing-our-planet/salt-of-the-sea.

EOSDIS Facilities

Data centers, collocated with centers of science discipline expertise, archive and distribute standard data products produced by Science Investigator-led Processing Systems (SIPSs)



EOSDIS Products Delivered: FY2000 thru FY2014



Recent and On-Going Developments (1 of 2)

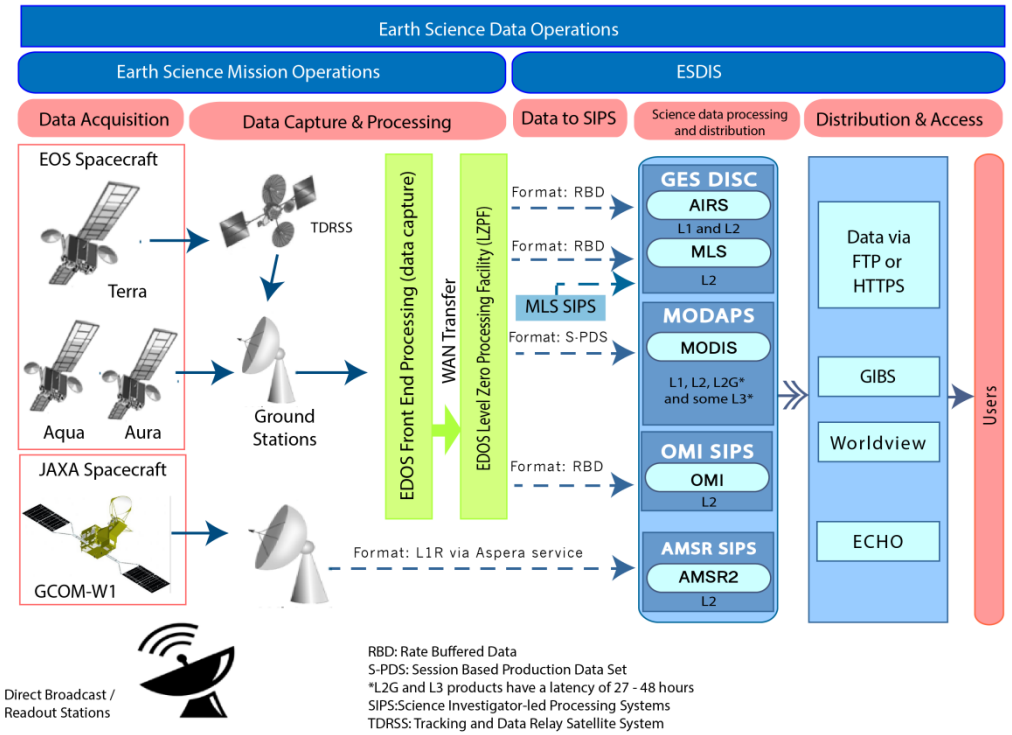
- **Land and Atmosphere Near real-time Capability for EOS (LANCE)**
- **Coherent Web Interface: http://earthdata.nasa.gov is operational**
  - **Provides a unified view of NASA Earth science data system resources**
  - **Consolidates 14 web sites, and provides links to various ways to access data and to related external sites**
- **User Registration System – uniform approach to registration across EOSDIS components**
- **Global Imagery Browse Services (GIBS)**
  - **Standards-based, full resolution, interactive browse capability**
  - **Accessible from http://earthdata.nasa.gov wiki**

Recent and On-Going Developments (2 of 2)

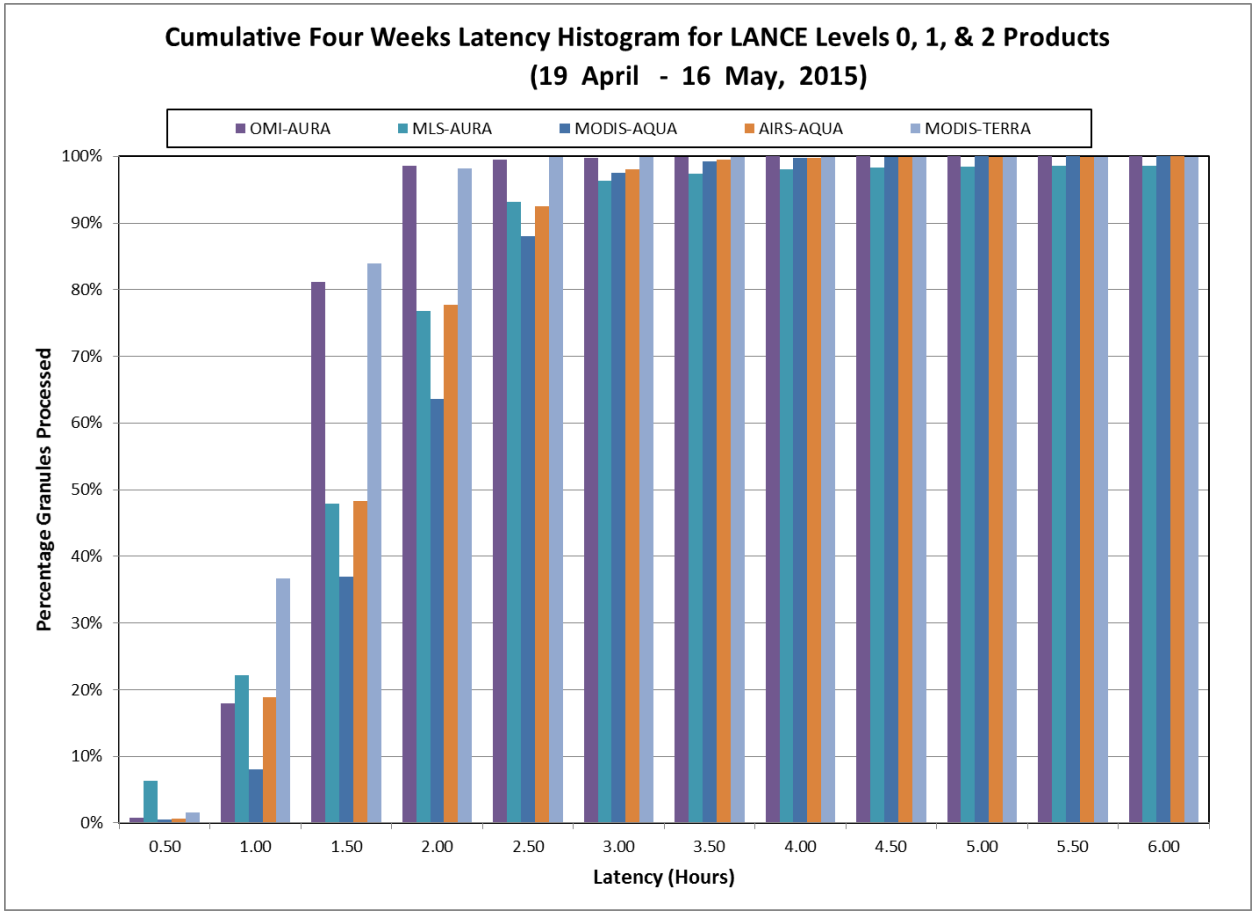
- **Metadata Architecture Study**
  - Initial Study made recommendations on adopting a common approach to metadata to improve user experience and reduce efforts by data providers
  - Phased approach to implementing recommendations
- **Unified Metadata Model and Common Metadata Repository**
- **Big Earth Data Initiative (BEDI)**
- **Preservation Content Specification**
- **Digital Object Identifiers**
  - ESDIS Project is a registration authority (prefix 10.5067)
  - DOI assignments to datasets in progress

Land, Atmosphere Near-real-time Capability for EOS (LANCE)

- **Building on existing EOSDIS elements provides data from MODIS, OMI, AIRS, MLS, and AMSR instruments in near real-time (< 3 hours from observation)**
- **Utilizes software for Standard Science Products, but relaxes requirements for ancillary data inputs**
- **High operational availability**
- **Applications of LANCE data include:**
  - **Numerical weather & climate prediction/forecasting**
  - **Monitoring of Natural Hazards**
  - **Disaster Relief**
  - **Agriculture**
  - **Air quality**



LANCE Latencies



Over the four weeks indicated above, >97% of near real-time data requests were satisfied within 3 hours.

EOSDIS Evolution: Earthdata Website

- **What is the Earthdata Website?**
  - Earthdata was created as a sustainable, evolvable, and reliable Website that represents our community's needs for NASA Earth science data and information.
  - It was designed to support collaboration within and between organizations, and for development and integration of new applications.
  - It addresses the need for a coherent and comprehensive Web presence of the Earth Science Data Systems Program.
  - See Earthdata at https://earthdata.nasa.gov/.

- **Benefits of the Earthdata Website:**
  - Better represents EOSDIS programmatic investments and capabilities.
  - Presents data centers more clearly as elements within a larger system of systems.
  - Facilitates multidisciplinary research and data integration.
  - More quickly responds to emerging technologies
  - Provides a platform for demonstration of interoperability throughout all of our systems.

EOSDIS Evolution: Worldview and Global Browse Imagery Services

GIBS / Worldview Goal:

To transform how users interact with and discover NASA Earth data; make it visual

Approach:

- The Global Imagery Browse Services (GIBS) provide open access to full resolution imagery derived from NASA products to any mapping client and script

  https://earthdata.nasa.gov/gibs

- **Worldview** is an open source, **browser-based client** to interactively explore GIBS (and SEDAC) imagery and download the underlying data

  https://worldview.earthdata.nasa.gov

Open-Access Servers

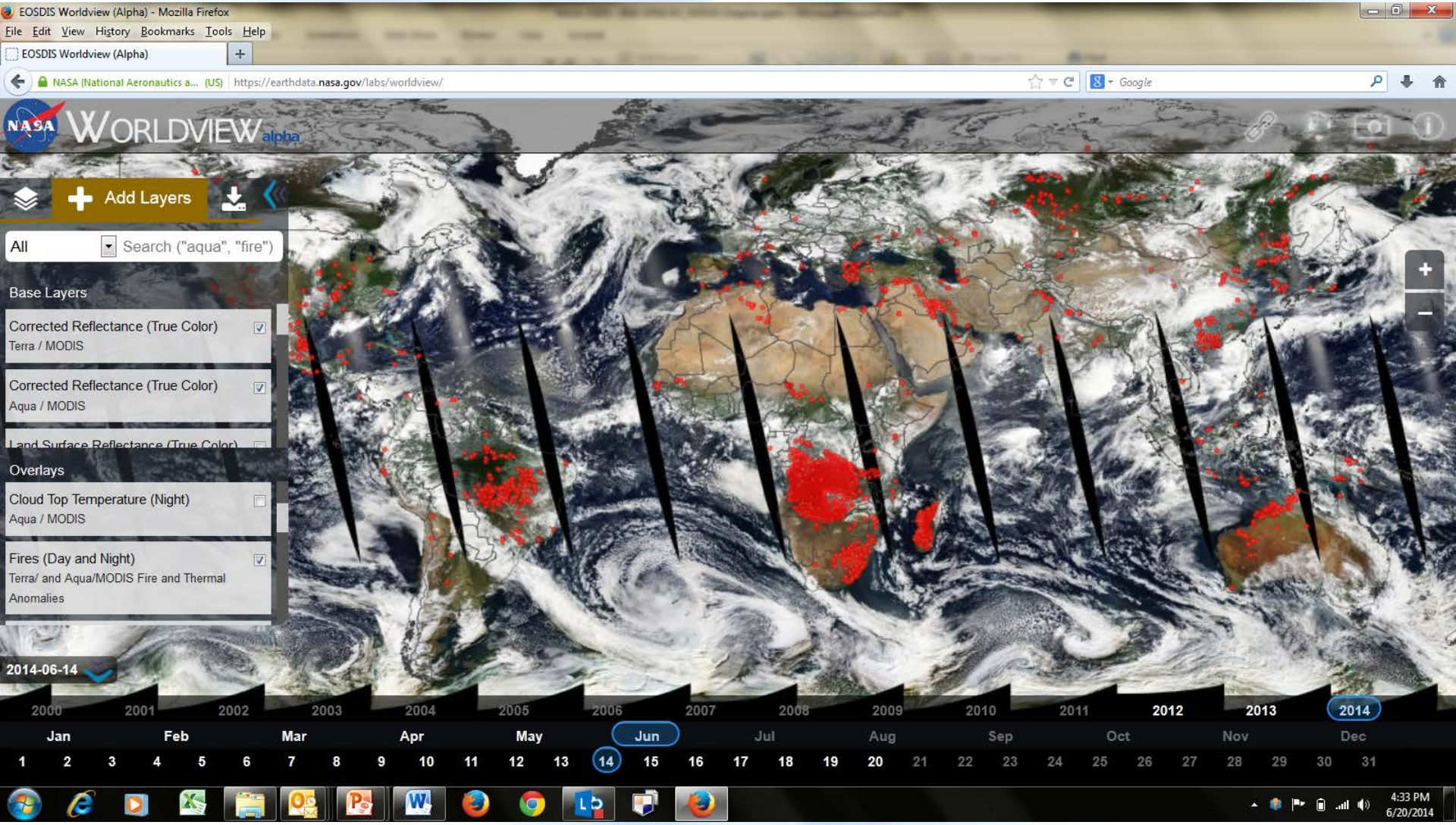
Client

Global Image Browse Service (GIBS)

- Goal: “Parameter Visualizations” for all EOSDIS Imagery
- Standardized access via OGC WMTS / TWMS / WMS / KML
- Source code for the GIBS OnEarth server and sample code available at the GIBS GitHub site
- Repository of pre-prepared, hierarchically stored imagery to maximize performance for “full-resolution” browse
- Clients can be built to use and display images in GIBS – WorldView is an example

Worldview: Reference Client for GIBS

http://earthdata.nasa.gov/worldview
http://earthdata.nasa.gov/gibs



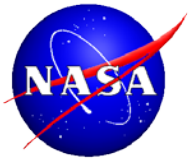
Data Tools

- Search and Order Tools (38)
- Data Handling (Read/Ingest, Format Conversion, Data Manipulation) (30)
- Subsetting and Filtering Tools (Temporal, Spatial, Parameter, Channel) (38)
- Geolocation, Reprojection, and Mapping Tools (29)
- Data Visualization & Analysis Tools (35)

Preserving NASA Earth Science Data

- **General requirements**
  - No loss of bits
  - Discoverability and accessibility
  - Readability
  - Understandability
  - Usability
  - Reproducibility of results
- **NASA has developed Preservation Content Specification for Earth Science Data**

Categories of Content to be Preserved



1. **Preflight/Pre-Operations:** Instrument/Sensor characteristics including pre-flight/pre-operations performance measurements; calibration method; radiometric and spectral response; noise characteristics; detector offsets
2. **Science Data Products:** Raw instrument data, Level 0 through Level 4 data products and associated metadata
3. **Science Data Product Documentation:** Structure and format with definitions of all parameters and metadata fields; algorithm theoretical basis; processing history and product version history; quality assessment information
4. **Mission Data Calibration:** Instrument/sensor calibration method (in operation) and data; calibration software used to generate lookup tables; instrument and platform events and maneuvers
5. **Science Data Product Software:** Product generation software and software documentation
6. **Science Data Product Algorithm Input:** Any ancillary data or other data sets used in generation or calibration of the data or derived product; ancillary data description and documentation
7. **Science Data Product Validation:** Records, publications and data sets
8. **Science Data Software Tools:** product access (reader) tools.

EOSDIS Evolution – On-Going with Community Inputs

- **Earth Science Data System Working Groups (on-going)**
  - focus on exploration and development of recommendations derived from pertinent community insights
  - organized around key technology and information system issues
  - Members from NASA-funded core and community data system activities
  - 2014-2015 Working Groups

- ❑ Airborne Data
- ❑ ASCII for Science Data
- ❑ Cloud Computing
- ❑ Data-Intensive Architecture
- ❑ Data Preservation Practices
- ❑ Data Quality
- ❑ Data Recipes
- ❑ Dataset Interoperability
- ❑ Digital Object Identifiers
- ❑ Geospatial
- ❑ Innovations Lab
- ❑ Open Source
- ❑ Provenance for Earth Science (PROV-ES)
- ❑ Technology Infusion
- ❑ Vision 2020
- ❑ Visualization

ESDSWG ←→ IEEE GRSS ESI TC

	ESDSWG	Earth Science Informatics Technical Committee
Processing	• Cloud Computing • Data-Intensive Architectures	• Cloud Computing • Spatial/Temporal analysis Tools • Earth system modeling tools
Archiving/ Stewardship	• Data Preservation Practices • Data Quality • Digital Object Identifiers • PROV-ES	• Preservation • Quality • Data stewardship • Provenance
Access	• Recipes • Dataset Interoperability • Visualization • Geospatial	• Knowledge representation and information models • Cyberinfrastructures • Interoperability and standardization • Data discovery and access • Web-based services and analysis • Geospatial information, knowledge, and decision support systems
Evolution/ Technology	• Innovations Lab • Open Source • Technology Infusion • Vision 2020	• Emerging information technologies and their applications in the geosciences • Sensor web and applications • spatial and process ontologies, vocabularies • semantic web
Other	• Airborne Data • ASCII for Science Data	• Data and information policies

Conclusion

- Earth Science Informatics is a rapidly developing discipline
- Many organizations around the world are actively pursuing ESI R & D
- Considerable commonality of interests among these organizations
- IEEE GRSS ESI TC, ESIP Federation, Research Data Alliance (RDA) are examples of groups promoting collaboration